

The Role of Industrial Technology in Enhancing Sierra Leone's Adaptation to Climate Change Mitigation

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Abstract: This research determines how industrial technology shapes Sierra Leone and related climate change patterns of the present and future. The research evaluates industrial resistance to climate adaptation obstacles and their potential technology usage to increase resilience. The industrial sector faces significant vulnerabilities during surveys and interviews, with power outages (32%), flooding (25%), supply chain problems (22%), and hot external temperatures (21%) demonstrating its significant vulnerabilities. The dependency on diesel-based fossil fuels at 62%, alongside limited adoption of renewable energy at only 18% solar power, demonstrates a matter of concern. According to research findings, 40% experienced flood-related issues, and 35% encountered drainage system problems. A shortage of climate-proof infrastructure exists throughout the entire nation. The use of open dumping methods at 46% and the practice of landfilling wastes at 32% hinders sustainable industry growth. Sierra Leone's industrial resilience against climatic challenges can be developed through renewable energy adoption, climate-proof infrastructure investments, and waste-to-energy program exploration, while environmental policies that combine financial benefits for sustainable practices and climatic education initiatives remain vital for development. The research demonstrates the need to develop modern technology to address specific industrial tensions affecting Sierra Leone. When combined with advanced technology and mechanisms for climate adaptation, the industry becomes more assertive and more environmentally friendly, leading to a sustainable economic growth pattern. The upcoming years will require us to analyze the role of industrial technology and financial instruments in accelerating climate change adaptation throughout the nation.

Keywords: Climate Change, Adaptation, Industrial Technology, Sustainability, and Sierra Leone.

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I. INTRODUCTION

Climate change is a serious global problem today, and it is touching economies, ecosystems, and livelihood across the entire world. It is particularly serious in economies like Sierra Leone, which have financial insecurity, bad infrastructure, and insufficient resources worsening ecological issues. Rising temperatures, unpredictable rainfall, and rising cases of floods, drought, and storms are serious concerns for Sierra Leone, a Western African nation. The phenomena impact agriculture, destroy infrastructure, are a burden for energy networks, and are threats to public health. Climate change poses a direct threat to livelihood in Sierra Leone since more than 50% of Sierra Leoneans engage in farming as a livelihood source. Irregular climatic conditions pose a threat

to farm yields, worsening poverty-induced hunger in rural Sierra Leone.

In addition, flooding and landsliding expose coastlines, bridges, and highways to greater risk--all needing greater investments--interrupting commerce and connectivity to vital services.

Familiar economic practices such as farming for livelihood and small-scale mining are important but are not resilient enough to meet rising challenges.

But there are opportunities for improvement in these challenges. Technological industry, in general associated with affluent economies, can be a source for breakthrough solutions for Sierra Leone. Technologies such as solar energy

systems, climate-resilient farm tools, and water conservation practices can raise productivity while protecting societies from climate dangers. As a good example, solar micro grids can replace dirty diesel generators, providing electricity to family and enterprise in a cleaner and more secure manner. Dry lands can be converted to fertile lands with precision irrigation technology.

Despite this, there are serious obstacles to progress. Sierra Leone's industrial sector is in a state of underdevelopment due to insufficient technical knowhow, out-of-date infrastructure, and insufficient investment. A number of businesses are short of funds to adopt advanced technology, while politicians are not able to formulate integrated resilience strategies for climate. Incoherent policies, inefficient governance, and lack of inter-sector cooperation are still hindering advancement. Unless they are addressed in time, societies may be at a higher risk for calamities caused by climate.

This research considers industrial technology as a force for transformation in Sierra Leone. It gives practical recommendations for mainstreaming renewable energy, revolutionizing farming, and enhancing resilience in infrastructure in response to climate risks based on Sierra Leonean vulnerabilities and opportunities. It considers how domestic societies, businesses, and state organizations can facilitate this transformation through smart investments, better policies or bottom-up invention.

Ultimately, this research is about closing the gap between aspiration and actual behavior. The vision is to empower stakeholders to create a future in which resilience and technology are balanced, and societies can not only survive but prosper in the face of climate change. It will be achieved through a tailored plan for Sierra Leone's circumstances.

➤ *Problem Analysis*

A series of major hindrances bars industrial technology from being integrated efficiently in Sierra Leone's climate adaptation plan. One key hindrance is Sierra Leone's insufficient infrastructure, barring advanced technology from being implemented and operated. Even highly efficient industrial solutions are not able to be up scaled without underlying infrastructure and are consequently limited in reach and supply in underserved and rural locations.

Financial constraints exacerbate the dilemma as the vast start-up expenses associated with industrial technology are a serious constraint for domestic organizations and state enterprises. The pace in adopting technology is slow as there is no significant external findings or novel financial strategies.

Furthermore, financial risks associated with investments, mainly volatility in rapid returns, discourage stakeholders from making investments in long-term technical progress.

A key shortcoming is a shortage of trained personnel to operate, keep in running condition, and upgrade industrial technology. The shortage in industrial technology and climate adaptation skill is severely hindering efficient and sustainable utilization of solutions. To bridge this gap, investments in vocational and training programs need to be undertaken in a major way in order to equip people.

With suitable skills. The application of industrial technology in climate adaptation is also being deterred in Sierra Leone by its lack of adequately strong policies and regulations. The lack of appropriate mechanisms for enforcement and lack of suitable incentives discourage businesses by adopting sustainable technologies.

Strong leadership in governance is needed to come up with policies for inducing industrial technology absorption and providing financial and regulatory assistance to interested parties.

In addition, there is still general opposition in society towards technology advancement. The movement towards sustainable solutions is hindered by reliance on traditional practices and skepticism towards innovative technologies. It is key to involving the population in detail, implementing public awareness programs, and providing real success stories exemplifying the virtues of industrial technology in adapting to climate change.

➤ *Aim and Objectives of the Research*

In this research, we intend to explore industrial technology as a possible way in which Sierra Leone can adapt to climate change. More specifically, we seek major technology advancements that ensure industrial sustainability and measure how they influence climate resilience.

The key research targets are as follows: To assess the influence of climate change on Sierra Leonean industrial performance and determine major climate threats to the industry. To quantify energy-efficient technology adoption, like biomass, solar, and wind, and how effectively they can curb industrial dependency on fossil energy. To discuss the advancement in climate-resilient infrastructure in studying innovative industrial practices and materials for improving industrial sustainability. To discuss sustainable industrial waste practices for recycling and recycling industrial wastes for manufacturing beneficial products like industrial products and industrial biofuels. To discuss policies and incentives at the state level, including tax relief and policies for utilization of renewable energy, and how they affect uptake in green industrial practices. (6) To discuss training and awareness programs and how they affect providing owners and industrial operators with information and skill for running climate-intelligent businesses.

II. LITERATURE REVIEW

Climate performance and industrial performance are connected in a major research agenda, and there are serious threats as there are opportunities for solutions. Consider a factory in Miami affected by a hurricane or a farm in India

affected by a drought; they are not just ecological issues but financial concerns as well. It is proven in research that climate-vulnerable enterprises suffer stunted growth and lower profits when extreme events interrupt them (Zhang et al., 2024). Climate-induced tragedies have shaken financial markets and undermined investor confidence, even in highly advanced economies as in the United States. Heatwaves are stealthy productivity killers. The European Central Bank (2021) elucidates rising temperatures can dip worker productivity, particularly in human-intensive enterprises like in farming and in construction, where human output is crippled in extreme heat.

Industries are adopting energy-conserving technology to address these challenges. Solar panels, wind turbines, and smart grids have grown from being innovative products to being must-have features. Studies have confirmed that improvement has driven down costs and boosted efficiency, making sources of energy derived from renewable sources available in larger numbers than ever before (Sova cool et al., 2020). The uptake is, nonetheless, proceeding at a slow pace. Industries unwilling to adopt energy-conserving upgrades in buildings are faced with staggering up-front expenses and insufficient expertise (Darko et al., 2018). Picture a factory manager in Lagos, Nigeria, torn between diesel generator reliability and dangers in investing in solar energy—a dilemma for many.

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Developing resilient infrastructure is equally as important. To combat heat islands, in industrial neighborhoods, for instance, cities like Paris are re-imagining urban space in creative forms by installing mist fountains and thousands of urban trees (Financial Times, 2023). It has been proven in research that installing renewable energy sources in energy networks is not only good for the planet but is a smart move for electricity-based businesses (Li et al., 2021). Think about buildings made out of flood-resistant concrete or factories lined in reflective coating—it is just simple measures but carries far-reaching implications.

An investigation area is in waste management. Industry 4.0: Blockchain and AI are revolutionizing supply chains as they follow waste from factories to recycling factories (Wang et al., 2023). Italian SMEs have proven circular economies are not theory as they recycle plastic waste for use in buildings and as a source for making biofuels (Trianni et al., 2013). It is recycling waste in one factory as raw material for another.

In spite of this, all this is in the context of policy. The governance is in the domain of the governments. Industries can be redirected towards being sustainable through use of incentives for sustainable enterprises, increased controls on pollution, and tax relief for adopters of solar energy. According to Timilsina et al. As cited in a report in 2017, these incentives allow businesses to overcome hindrances like raised costs. The OECD (2024) posits investing in climate resilience saves lives while generating jobs and

improving economic growth, leading to human and nature benefits as well.

Despite this, laws and technology are not enough. Workers need to be able to cope with this transformation. Training in learning solar maintenance and drought-resistant farming techniques is key. Studies have shown organizations with technologically trained staff and vision leaders are able to transform quickly, translating ecological risks into opportunities (Zhao et al., 2022; Huang et al., 2023). Envision a creative-inspired staff, in which supply chains are being redesigned for sustainable futures by managers, or a factory engineer in Sierra Leone designing solar system solutions.

Generally, the literature communicates one unmistakable message: multiple solutions such as smart infrastructure, clean energy, smart policies, and engaged citizens are needed for climate resilience to be achieved. The message is unmistakable for businesses in industry after industry: adapt or perish. The catch is in being efficient in making use of the tools.

III. RESEARCH METHODOLOGY

A. *The Study Area*

Sierra Leone is a rich testing bed for climate adaptation, featuring dense tropical forest alongside vibrant urban hubs and arid farmland. Along Western Africa's coast, Sierra Leone is as breathtaking as it is vulnerable. Heatwaves devastate farming in Bo, tropical rains flood Freetown urban hubs, and erratic dry spells drain energy out of river waters that supply industry. Climate change is a reality in everyday lives and livelihoods, and not some distant threat.

Based on Sierra Leone's industrial center, Freetown, Bo, Kenema, and Makeni each have a different story about resilience and resourcefulness. Freetown factories are located near busy thoroughfares and suffer supply breakdown caused by flooding. As an agricultural town, Bo is faced by drought, destroying rice and cassava plantations, vital to economy and cuisine in Sierra Leone. The mining sector in Kenema, vital to Sierra Leonean GDP, is faced by loss of topsoil as a result of unpredictable rainfall. As temperatures and diesel prices go up, Makeni's rising energy sector is faced by ensuring supply in electricity.

They are a microcosm for Sierra Leone's experiment in achieving a balance between survival and development and are not random locales on a map. The research shows how technology can transform the landscape in targeting major industrial centers. How can Freetown factory use solar energy when there is a power breakdown? Does AI have the potential to detect flood risks for the mines in Kenema? What are some feasible solutions for using industrial and domestic wastes as energy sources?

➤ *Lower Overheating of Food Processors in BO*

The research is based on insights obtained from varied players in the field in tackling some of these issues, for instance, engineers repairing solar panels on roofs composed of tin, state officials making policies in candlelight since there

is no electricity, flood plans being drawn up in old computers by environmental experts, and factory managers dealing with broken-down machinery. Practical solutions like stocking warehouses with flood-proof supplies or training employees to transform plastics into building supplies will be based on their stories. It is not about numbers but about human beings. The idea is to develop a resilience plan in partnership with Sierra Leonean businesses and consider how technology can fix things and restore optimism. The intention is to keep factories running, save jobs, and have society be resilient in the face of altered climatic conditions.

B. Research Design

In examining Sierra Leonean industrial sector climate adaptation practices, this research applied a descriptive research design and utilized a combination of qualitative and quantitative research approaches.

C. Data Collection Methods

➤ **Primary Data Collection**

Surveys and Questionnaires: A total of 200 surveys had been sent to industrial business owners, policymakers, and engineers, and we had responses back from 150, or a response rate of 75%. **Semi-structured interviews** consisted of a total of fifteen key stakeholders, including leaders in businesses, government, and climate specialists. **Focus Group Discussions (FGDs):** To gather diverse perspectives on climate adaptation, three FGDs were organized, each consisting of eight to ten participants, including engineers and blue-collar employees. Field visits to five industrial sites in Freetown, Bo, and Makeni were conducted in an attempt to assess energy use, waste disposal practices, and resilience in infrastructure.

➤ **Secondary Data Collection**

Government Documents: A review was conducted of industrial sector policies and policy documents, such as Sierra Leone National Climate Change Strategy and Action Plan (2020). Published research articles have been read in order to provide academic background in industrial sustainability and

climate resilience. Reports of international organizations: To have a comparative vision for climate adaptation plans, we have studied international organizations' reports like the OECD, World Bank, and UNEP.

D. Data Analysis

➤ **Quantitative Data Analysis**

Descriptive statistics have been applied in measuring industrial sector climate adaptation strategies and energy efficiency. Besides, regression analysis was applied in studying industrial productivity and climate adaptation strategies. SPSS software was applied in managing data.

➤ **Qualitative Data Analysis**

Thematic analysis was utilized in extracting recurring themes in interview and focus group meetings. NVivo software was used in coding and examining qualitative data. Content analysis was utilized in policy documents in assessing how they contribute to supporting processes of climate adaptation.

IV. DISCUSSION OF RESULTS

A. Industry and Climate Change

Surveys and interview responses affirm that industrial processes in Sierra Leone are adversely affected by climate change, as exemplified in Sierra Leone's regular power outages, extreme climatic phenomena, and supply chain failure.

Table 1: Impact of Climate Change on Industrial Operations

Climate change Impact	Percentage of Industries Affected (%)
Power outages	32
Flooding	25
Supply change Disruptions	22
External Heat	21
Total	100

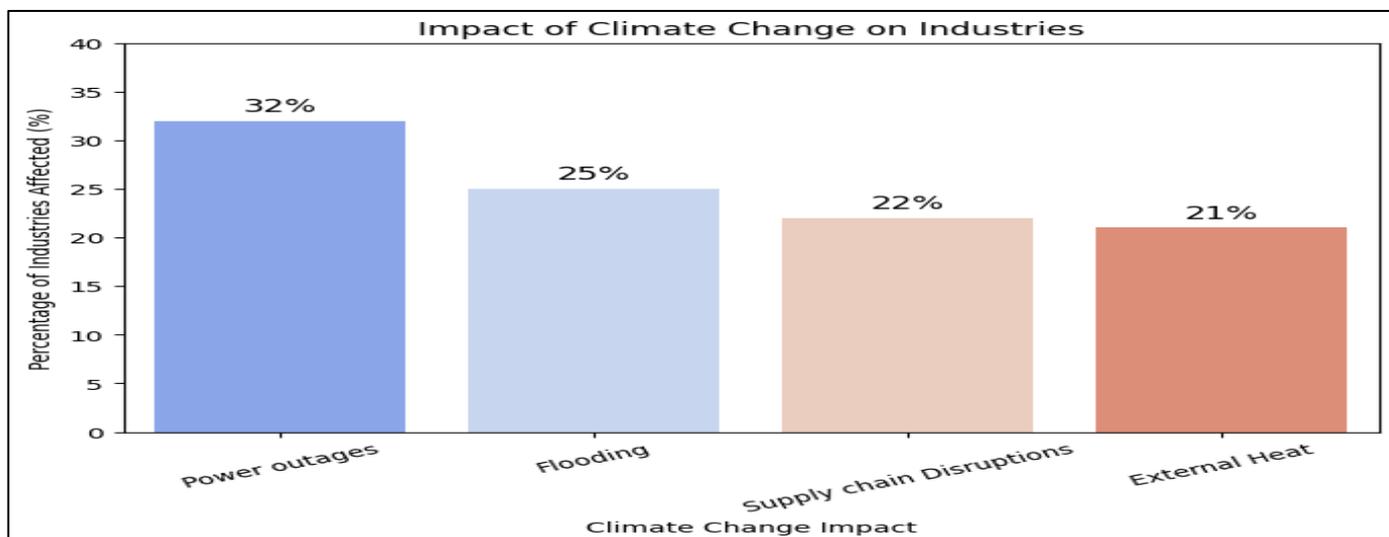


Fig 1: A Bar Graph Illustrating the Proportion of Industries Impacted by Various Effects of Climate Change

Figure 1 illustrates Sierra Leone industrial sector is highly vulnerable to climate change. The prevalence in power outages in 32% of businesses confirms there is a need for energy diversification and improvement in infrastructure urgently. As in line with report of Ebinger and Vergara (2011) who state erratic electricity is a cause of industrial productivity and economic improvement in poverty-ridden economies, Sierra Leone weakened energy system is being overstretched since there is increased prevalence in extreme climatic conditions like heat waves and storms and thus making businesses vulnerable to outages.

25% are impacted by flooding, and for this reason there is a need for improved drainage systems and increased infrastructure in place urgently. Ineffective flood preventive mechanisms have been shown to increase industrial loss and disrupt economical processes, as is illustrated in research like Adelekan (2012) on urban climatic risks in West Africa. Adaptive infrastructure is key for sustainable outcomes in the longer term since coastlines are highly susceptible to sea level rise and extreme rainfall events.

Supply chain disruption is another threat as serious and affects as much as 22% of businesses. The increased unpredictability in extreme climatic conditions complicates manufacturing schedules, raw supplies, and logistics schedules. Sarkis et al. A discourse in 2020 had opined that supply chains in Africa are susceptible to climate change and require mechanisms for adaptation in forms like domestic manufacturing, multiple sources for raw supplies, and improved logistics control. Without them, businesses would still be vulnerable to inefficiencies in processes and financial loss.

21% are impacted by outdoor heat, at risk for worker productivity, and for increased cooling costs and for lower total operational efficiency. As cited in Kjell Strom and colleagues. As cited in a report in 2018, tropical climates' increased heat severely affects labour productivity, particularly in outdoor enterprises such as farming, mining, and construction. The impact caused by power outages is exacerbated by increased temperatures, as energy demand for cooling systems is increased. Ensuring industrial productivity in climatic conditions includes implementing heat managing practices, alongside improved cooling and better ventilation processes and rationalized schedules for labour.

In general, these findings validate legislative reforms, climate adaptation plans, and investments in resilient infrastructure as being necessitated in a move to shield Sierra Leone's industrial sector from climatic shocks. As industry is rendered sustainable in the future, research should be sector-based and come up with solutions aimed at each sector.

B. Promoting Energy-Efficient Technologies

Industries primarily rely on fossil fuels, with limited adoption of renewable energy solutions.

Table 2: Energy Sources Used by Industries

Energy Source	Percentage Usage (%)
Disel Generators	62
Grid Electricity	18
Solar Energy	12
Biomass	8
Total	100

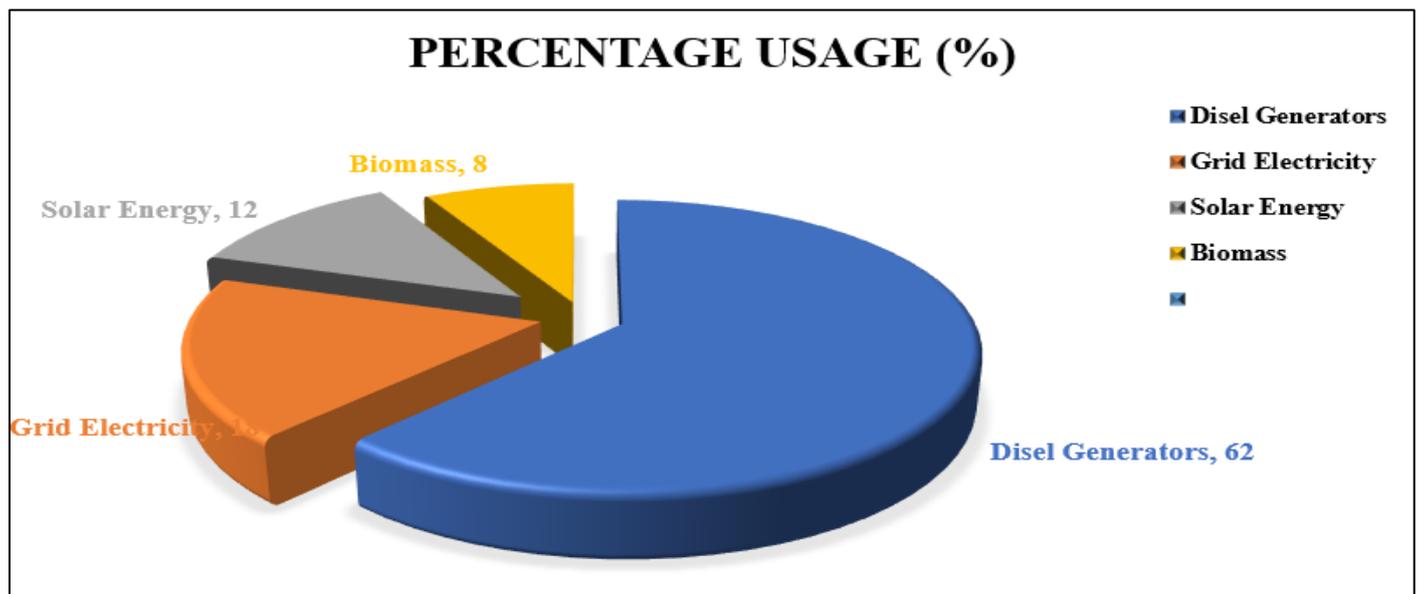


Fig 2: A Pie Chart Illustrating the Proportion of Different Energy Sources used in the Industrial Sector

Figure 2 information reveals a major dependency on diesel generators, at 62% usage in businesses. The excessive use contributes to problems for the economy and for the environment in the form of increased costs and significant carbon emissions.

Diesel is widely used as a result of grid electricity unreliability, leading businesses to explore alternative sources of energy in order to continue running.

An 18% solar energy uptake is a reflection of rising interest in alternative sources of energy. The high up-front expenses associated with solar installations are principally to blame for relatively lower acceptance. However, solar energy is a viable alternative inasmuch as it involves lower running expenses and a lower negative impact in the longer term.

Government subsidy and capacity-building programs can contribute greatly towards making available lower-cost renewable energy technologies and making them competitive for businesses.

Twelve percent is obtained from grid electricity for industrial energy use. The limited utilization of grid electricity is indicative of issues discouraging enterprises from wholly relying on this source, including irregular supply and insufficient supporting infrastructure. By ensuring grid electricity is available and regular, enterprises can be encouraged to use it, thereby reducing utilization of more expensive and environmentally unsustainable sources.

In industrial economies, biomass supplies 8% in energy content. Biomass is still a prominent source of energy in Sierra Leone, especially for domestic use, though industrial use is fairly modest. The biggest source is wood fuel, and in second place is charcoal.

C. Developing Climate-Resilient Infrastructure

Because they lack climate-resilient infrastructure, industrial zones are susceptible to severe weather events.

Table 3: Infrastructure Vulnerabilities in Industrial Zones

Infrastructure Issue	Percentage of Industries Affected (%)
Flood Damage	40
Poor Drainage	35
Inadequate Cooling	26
Total	100

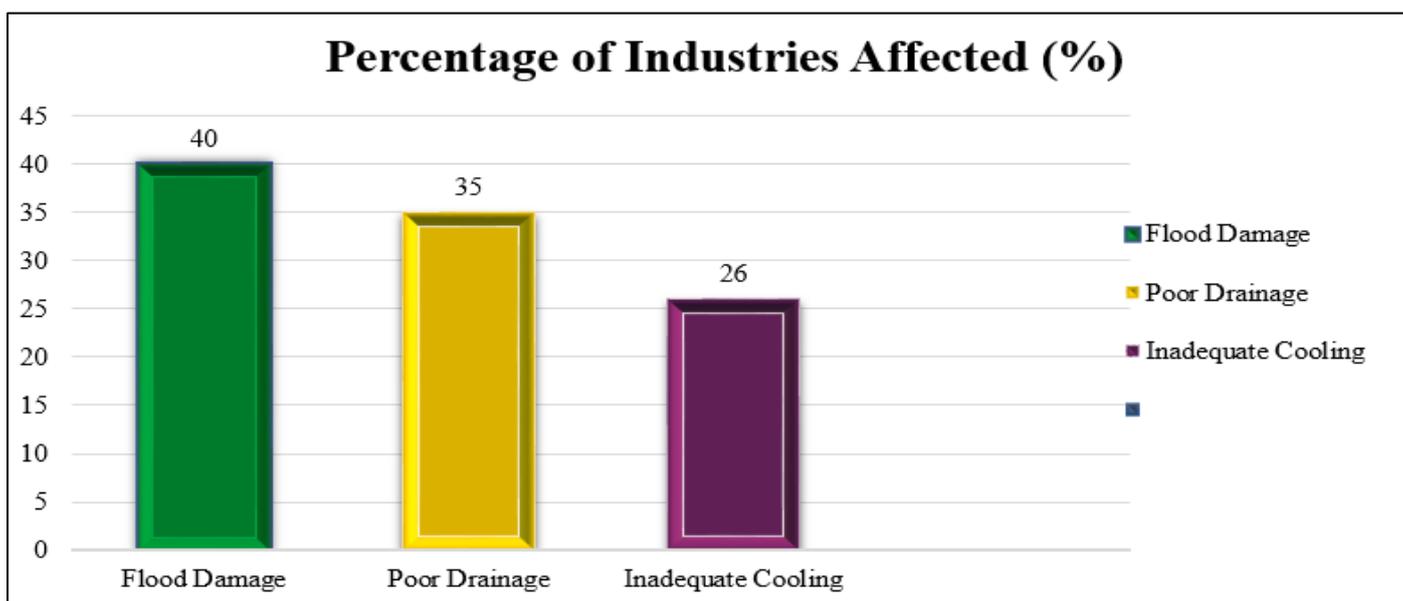


Fig 3: A Bar Chart Illustrating the Percentage of Industries Affected by Various Infrastructure Issues

Figure 3 statistics confirm that much of Sierra Leone's industrial sector is being confronted with vulnerabilities in infrastructure caused by climate change. The most prevalent is flood damage, and it occurs in 40% of industrial locations. The consistency at which this is occurring is symptomatic of Sierra Leone being susceptible to increased sea level rise and increased rainfall, opening it and industrial processes to loss and interference. The World Bank observed that lack of connectivity and problems in infrastructure caused or aggravated by climate change are hindering manufacturing in Sierra Leone.

35% state there is insufficient drainage in their industry, and this is greatly connected to flooding problems. Inadequate drainage causes water to pool in excess rains and can be damaging to tools and problematic in running processes. It is essential in flood impact mitigation in industrial processes to resolve drainage problems.

A quarter have no cooling and thus have difficulty in maintaining their ideal temperatures, especially in extreme heatwaves. The International Monetary Fund (IMF) reveals Sierra Leone is being impacted by climate change and some associated effects include rising temperatures and rising numbers of extreme hot days. The conditions may be straining the cooling system in Sierra Leone and hindering industrial productivity.

In brief, in these findings, it is noted that over half of the industries experience climate change-induced problems in infrastructure. Combining industrial strategies and climate-resilient designs is key to ensuring sustainable practices in the future. Adaptive solutions can be refined based on tapping human and financial capacities and expertise in collaboration and promotion of public-private partnership in infrastructure. Joint efforts are needed for enhancing resilience to climate risks in Sierra Leone industry.

D. Enhancing Industrial Waste Management

With little recycling and waste-to-energy programs, waste management in Sierra Leone's industrial sector continues to be a significant concern.

Table 4: Industrial Waste Management Practices

Waste Management Practice	Percentage of Industries Using (%)
Open Damage	46
Landfilling	32
Recycling	22
Total	100

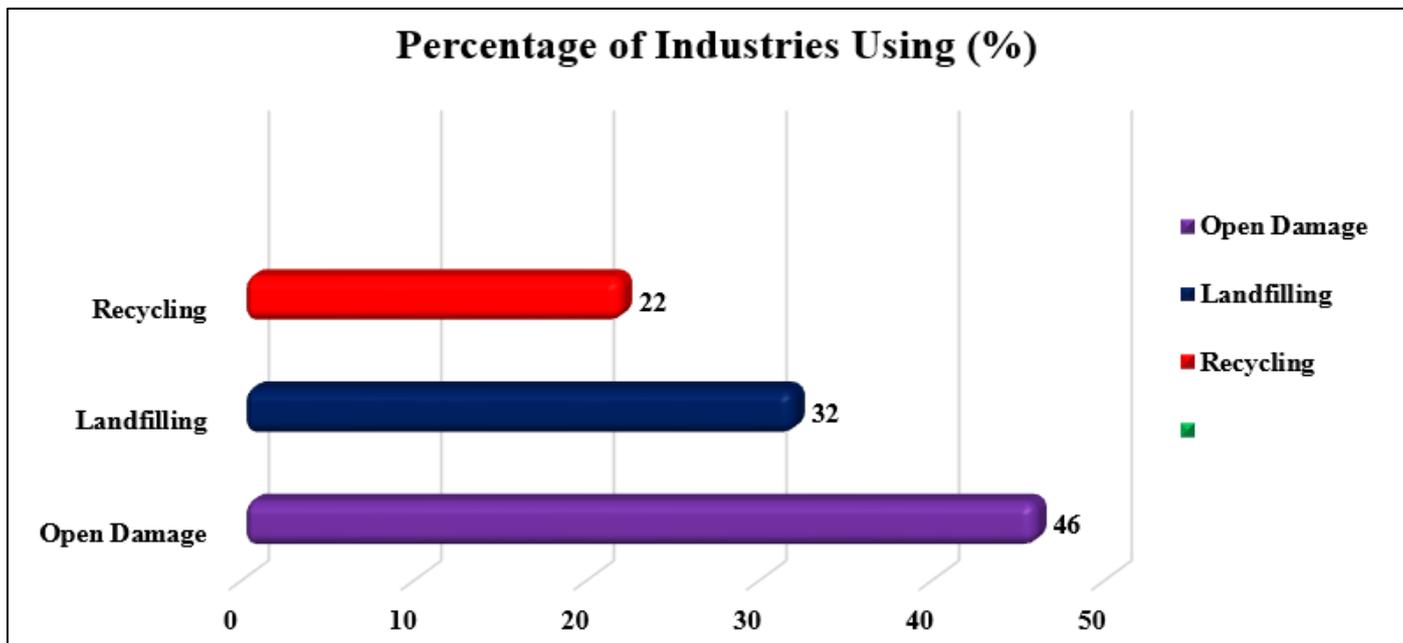


Fig 4: A Bar Chart Comparing Different Industrial Waste Disposal Methods

Data in figure 4 reveals disturbing trends in industrial practices for managing wastes. A total of forty-six percent use open dumping, a highly unsafe and polluting method and poses health and ecological risks like water and soil contamination. In locales without suitable collection and disposal mechanisms for wastes and without official garbage disposal mechanisms, open dumping is prevalent in industry. The inefficient garbage collection and disposal mechanisms in developing countries are highlighted as worsening problems associated with public health, as cited by the World Bank. Cause health and environmental harms. Although it is a highly controlled method, landfilling, as used in 32% of cases, is still subject to limitations, some being potential leachate pollution and land use issues. In order to prevent or at least reduce these risks, Sierra Leone's National Waste Management Strategy emphasizes efficient practices for managing wastes. Although recycling is being applied in 22% of businesses, it is still the least utilized method. The reasons for this include financial constraints, lack of appropriate infrastructure, and lack of awareness in general. The United Nations Environment Programme (UNEP) mentions training and capacity building as being instrumental in improving Sierra Leone's practices in managing wastes. Formulating and enacting strict policies for managing wastes in a way that promotes recycling and building waste-to-energy plants is instrumental in enhancing sustainability. Waste-to-energy

processes ensure minimized use of landfills and play a vital role in achieving circular economy as unrecyclable are utilized as usable energy in forms such as heat and electricity. Furthermore, supporting circular economy practices can contribute towards minimized waste and improved resource use. In Sierra Leone, there is a need to invest in industry waste management infrastructure as well as to conduct awareness programs and population capacity-building programs in a move aimed at improving sustainable industry waste management.

E. Encouraging Policy Reforms and Incentives

There is weak enforcement of environmental policies, and industries lack incentives to adopt sustainable technologies.

Table 5: Awareness and Implementation of Industrial Climate Policies

Policy Awareness Level	Percentage of Industries (%)
Aware of Regulations	65
Compliance with Regulations	35
Total	100

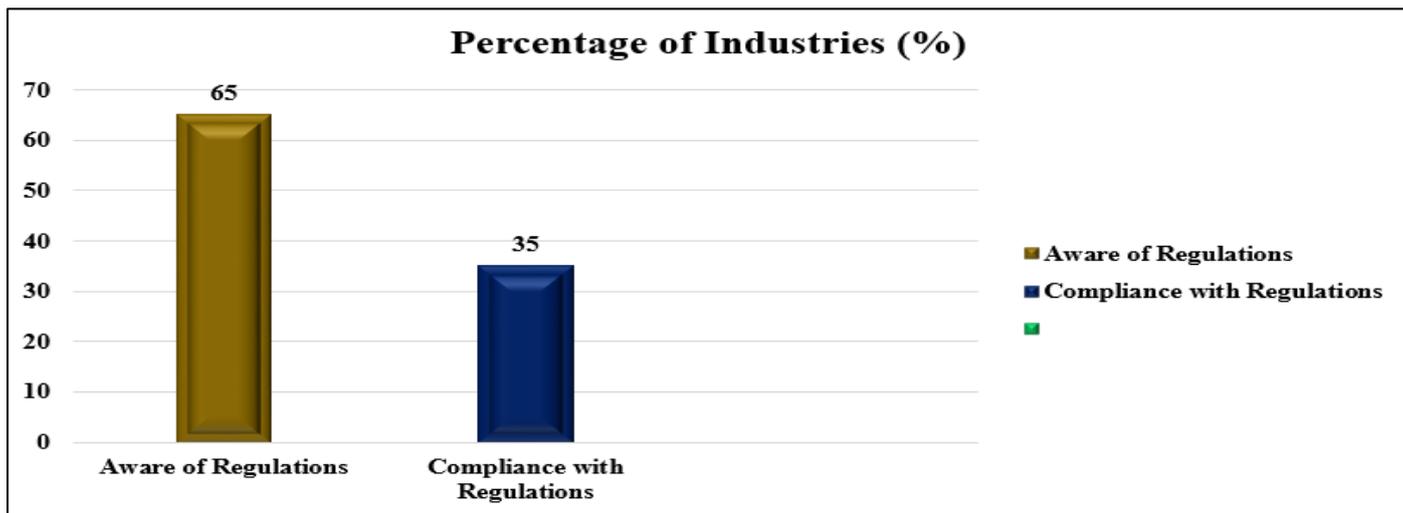


Fig 5: A Bar Chart Illustrating the Percentage of Industries Aware of and Compliant with Environmental Regulations

Figure 5 illustrates there is a major difference in awareness and compliance amongst businesses towards environmental standards. Awareness exists in 65% of the businesses but compliance exists in only 35%, resulting in a compliance deficit of 30%. The difference is reflective of potential limitations in following suitable strategies for compliance, insufficient funds, or financial constraints, and awareness alone is insufficient to ensure adherence. Several reasons are why compliance in developing countries is as low as it is. It has been established in research that regulations are normally created without much thought given to conditions in and available resource in the area, thus being problematic to implement.

In addition, issues such as corruption, bias, and inefficient enforcer strategies can compromise the effectiveness of environmental policies. Moreover, lack of sufficient financial rewards and assistance for sustainable investments may deter businesses to opt for sustainable practices.

Proper deployment of resources for compliance and monitoring and supporting processes for enforcement is key

to bridging this compliance shortfall. Fiscal incentives in terms of tax relief and subsidy for sustainable investments can incentivize industry towards adopting climate-savvy practices. Encouraging public-private partnership can enable resource and expertise pooling and can go towards making industry sustainable. With solutions to problems and supportive policies in hand, enterprises can be better equipped to meet environmental regulations and achieve better environmental performance and sustainable industrial development.

F. Strengthening Capacity Building and Awareness

There is a lack of technical expertise in climate adaptation strategies across industrial sectors.

Table 6: Availability of Climate Adaptation Training

Training Availability	Percentage of Industries (%)
Provides Training	32
No Training	68
Total	100

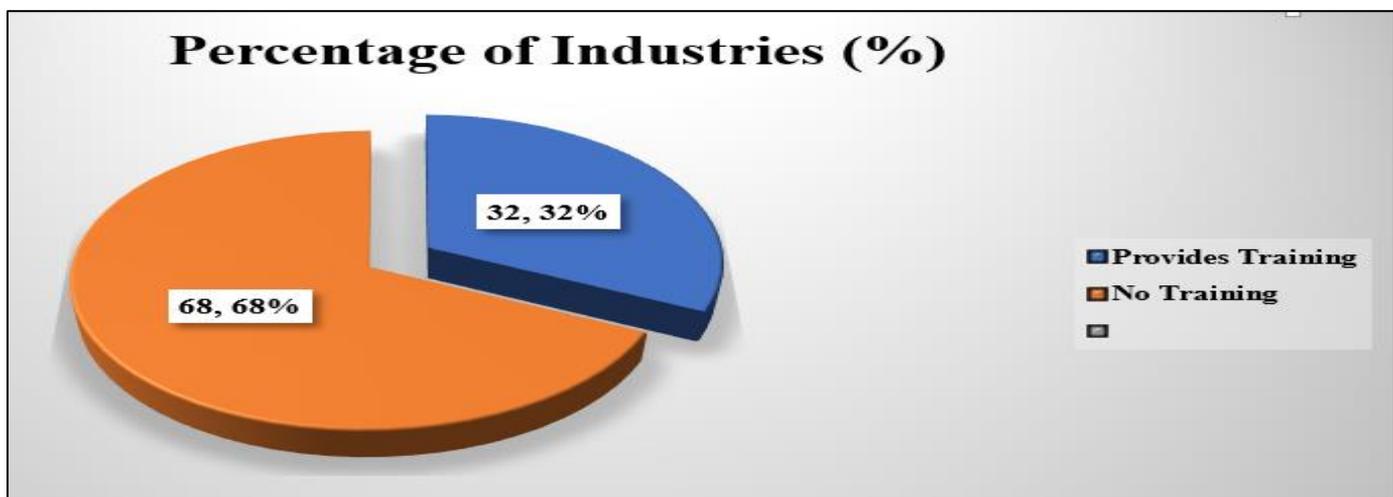


Fig 6: Availability of Climate Adaptation Training Programs

Figure 6 shows that only 32% have training for climate adaptation and there are 68% without training available. The difference is indicative of a serious shortcoming in the industrial sector in achieving resilience to climate change. Small and medium enterprises (SMEs) play a major role in generating innovation and resilience, as recognized by the United Nations Industrial Development Organization (UNIDO). They attach much importance to industrial skill in being able to adapt to climate change. Collaboration among schools, research institutes, and the state is instrumental in bringing this gap. Collectively, they can develop tailored training programs for each company depending on their individual requirements, making them better equipped to carry out climate adaptation strategies effectively. Moreover, through information exchanges and technology, these programs can be instrumental in supporting sustainable industrial practices.

For instance, UNIDO implemented programs in Sierra Leone for tackling climate change issues through entrepreneurship and innovative solutions. As a measure for enhancing farmers and businesses resilience, programs highlighted providing farmers and businesses with access to state-of-the-art climate adaptation solutions and technology, for instance, solar water pumps, solar-powered freezers, and cold storage units. The United Nations Development Programme (UNDP) is actively improving Sierra Leone's early warning and climate information system, vital for making informed decision-making and adapting to climate change effectively.

With the utilization of these programs and alliances, organizations are able to better adapt to climate change and thus have more sustainable industrial processes.

V. CONCLUSION

Proof demonstrates that industrial technology is necessary for Sierra Leone to handle changing climate patterns. Studies indicate that climate-based disruptions create important disturbances in the industrial sector by inducing electrical power outages and floods, disrupting manufacturing supply networks, and producing deadly heat waves. Heavy use of fossil fuels to operate dielectric generators creates economic and environmental deterioration. Progress toward solar example-based renewable power systems faces two significant obstacles: funding barriers and necessary infrastructure development. Pillar to improve climate resilience will depend on two essential factors: developing energy-efficient technology and spending funds on sustainable infrastructure and better waste management systems. Combining established sustainable practice support policies with financial incentives enables manufacturing companies to adopt green industrial approaches. Various climate adaptation strategies demand proper skills and knowledge among industry stakeholders that capacity-building programs and awareness enhancement can provide. Sustained industrial success in Sierra Leone requires all relevant parties to work together under government supervision with private businesses and research institutions. Strategic policy implementation and technological

developments will create opportunities for Sierra Leone to build industrial endurance and reduce environmental impacts, resulting in enduring economic success during climate change fluctuations.

➤ *Recommendations for Enhancing Industrial Resilience to Climate Change in Sierra Leone*

A number of steps are suggested in order to enhance industrial sector resilience to climate change:

- **Diversify energy sources:** Companies can use alternative energy sources such as solar and wind energy in place of diesel-based generators. It would lower carbon footprint and maintenance expenses and be a contribution towards achieving worldwide sustainability targets. The United Nations Industrial Development Organization (UNIDO) is currently supporting this shift in Sierra Leone by offering solar freezers and water pumps to farmers and enterprises.
- **Improve Infrastructure Resilience:** Climate-resilient investments are required in infrastructure. It includes adapting cooling solutions to avoid heat stress and improving drainage systems to avoid flooding. The cause is being supported in providing funds for improving Sierra Leone's market and transport connectivity in a climate-resilient manner by The World Bank.
- **Enhance Waste Handling Practices:** Industries need to incorporate sustainable practices for handling wastes like recycling and waste-to-energy technology in a bid to lower their footprint in nature. The Green Climate Fund is supporting Sierra Leonean initiatives for bettering waste handling and circular economy practices.
- **Increase Policy Compliance and Enforceability:** It is highly important to ensure better compliance and enforcement of policies. It can be attained by revising outmoded legislative frameworks and ensuring sufficient funds are allocated for compliance and monitoring. The need for more proactive risk analysis and better disaster risk management in Sierra Leone has been emphasized by the International Monetary Fund (IMF).
- **Invest in Training and Capacity Building:** Training industry players in climate adaptation will enable them to incorporate sustainable practices in their businesses. Government, research, and academic partnership can be leveraged in creating customized training programs for individual businesses depending on their unique requirements. An example is in UNIDO programs in Sierra Leone.

REFERENCES

- [1]. Darko, A., Chan, A. P. C., Ameyaw, E. E., He, B. J., & Olanipekun, A. O. (2018). Examining issues influencing green building technologies adoption: The United States green building experts' perspectives. *Energy and Buildings*, *144*, 320-332. <https://doi.org/10.1016/j.enbuild.2017.12.070>
- [2]. European Central Bank (ECB). (2021). The impact of climate change and policies on productivity. Retrieved from

- <https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op340~0173592e52.en.pdf>
- [3]. Financial Times. (2023). Global cities grapple with how to cool 'urban heat islands'. Retrieved from <https://www.ft.com/content/e598e669-046e-4fb4-87a3-cf7f69f6c7e3>
- [4]. Huang, Y., Wu, J., & Zhang, B. (2023). Climate change exposure and firm performance: Does managerial ability matter? *Sustainability*, 15(17), 12878. <https://doi.org/10.3390/su151712878>
- [5]. Li, W., Pan, Y., & Lam, J. C. (2021). Towards climate resilient urban energy systems: A review. *National Science Review*, 8(3), nwaa134. <https://doi.org/10.1093/nsr/nwaa134>
- [6]. Sovacool, B. K., Furszyfer Del Rio, D., & Griffiths, S. (2020). A systematic review of energy-efficient technologies and their impacts on sustainable development. *Energy Research & Social Science*, 68, 101541. <https://doi.org/10.1016/j.erss.2020.101541>
- [7]. Timilsina, G. R., Meij, R., & O'Neill, J. (2017). How do policies influence energy efficiency in industry? Evidence from OECD countries. *Energy Policy*, 108, 355-370. <https://doi.org/10.1016/j.enpol.2017.05.017>
- [8]. Trianni, A., Cagno, E., & Spina, P. (2013). A taxonomy of energy-efficient technologies in small and medium-sized manufacturing enterprises: Drivers and barriers to adoption. *Journal of Cleaner Production*, 40, 8-18. <https://doi.org/10.1016/j.jclepro.2012.08.039>
- [9]. Wang, L., Xie, H., & Zhang, X. (2023). Advanced digital technologies in sustainable supply chain management: A framework for low-carbon strategies. *Computers, Environment and Urban Systems*, 95, 101810. <https://doi.org/10.1016/j.compenvurbsys.2022.101810>
- [10]. Zhang, Y., Wang, X., & Wang, Z. (2024). Extreme weather and firm performance: Evidence from the U.S. stock market. *Journal of Financial Economics*, 142(1), 1-19. <https://doi.org/10.1016/j.jfineco.2023.10.004>
- [11]. Zhao, J., Zhou, J., & Liu, Z. (2022). Technological innovation and energy efficiency: A study on the role of industry structure. *Energy Economics*, 108, 105883. <https://doi.org/10.1016/j.eneco.2022.105883>
- [12]. Organization for Economic Co-operation and Development (OECD). (2024). Climate-resilient infrastructure investment: Policy implications. *OECD Environment Working Papers*. <https://doi.org/10.1787/79d66b52-en>
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CONTRIBUTIONS

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